extraordinary bright cloud, displaced towards the less refrangible portion of the spectrum, appeared near the upper end of the C line. The line K 654·3 was almost as bright as C, but was not displaced. This brilliant portion of the chromosphere proved to be the beginning of a large prominence, and as the prominence increased in height the line K 654·3 faded away, becoming invisible where the prominence was highest and brightest. On sweeping back to the former position the bright cloud was found to have disappeared, and both C and K 654·3 were somewhat less brilliant than before.

The solar drawing on June 2 shows that a moderately large group of spots was just on the limb at the point where K 654·3 was seen on May 30. Another larger group of spots has burst out since May 30, and is already past the centre of the disk.

Stonyhurst Observatory:
1883, *June* 5.

Note with respect to the Limb of the Planet Jupiter.

By A. C. Ranyard, M.A.

At a recent meeting of the Astronomical Society Capt. Noble stated that, in observing an eclipse of *Jupiter's* fourth satellite on April 4, 1883, he was struck with the slow manner in which the light of the satellite disappeared and flashed up again at intervals, so brightly that he could not persuade himself that the changes of light were due to scintillation or disturbance in the Earth's atmosphere. Mr. Marth showed that the slow disappearance was due to the fact that the satellite, on the occasion referred to, entered the northern edge of the cone of shadow cast by the planet very obliquely; but the flashing up again of the light of the satellite at intervals was not explained. Direct observations of *Jupiter* point to the existence of an extensive atmosphere in which great masses of cloud are suspended, I would suggest that the flashing up at intervals of the light of the satellite was due to its passage through darker regions in the penumbra of the planet's shadow caused by clouds in the atmosphere of *Jupiter*. The oblique passage of the satellite through the penumbral region of the shadow, probably causing the changes of illumination to last for a longer period than on ordinary occasions, when the satellite plunges more perpendicularly into the cone of shadow.

The object of the present note is to bring together some observations of eclipses of *Jupiter's* satellites and occultations by the limb of the planet, which tend to show that *Jupiter* has not a definite, hard outline, but that the limb is partially transparent with here and there regions of greater opacity.

Dr. T. D. Siminton, of St. Paul, U.S.A., observed the previous eclipse of the fourth satellite. On that occasion the

satellite only just grazed the northern edge of the shadow cone. An account of the observation is given in the *Sidereal Messenger* for April 1883. Dr. Siminton says: "The light of the satellite rapidly decreased till $10^h\ 55^m$, when, if visible at all, the light of the body was excessively faint. This continued but a minute or two, when I was sure of it again by glimpses, and in a minute or two more, before $11^h\ 0^m$, I could see it steadily." The observation was made with a 3-inch achromatic.

On April 26, 1863, Mr. S. Gorton observed an occultation of the second satellite. An account of the observation is given in the *Monthly Notices*, xxiii. p. 217. He says "the occultation occupied nearly seven minutes, during which time, owing apparently to the movement of the atmosphere, the satellite seemed to disappear and appear again several times."

On October 5, 1878, Mr. Todd, the Director of the Adelaide Observatory in South Australia, observed an eclipse of the fourth satellite. An account of the observation is given in the *Monthly Notices*, xl. p. 175. He says in a note with respect to the time of disappearance: "Time considered exact, but lost sight of satellite several times before final disappearance; planet not well defined; Moon a little to east of planet."

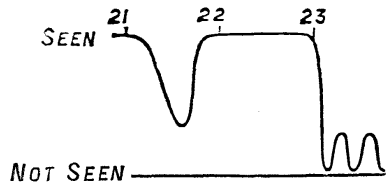
On Sept. 14, 1879, Mr. J. Turner observed an occultation of 64 *Aquarii* with the great Melbourne Reflector and a power of 350. An account of the observation is given in the *Monthly Notices*, xl. p. 141. He says: "At the moment of contact the star did not instantly disappear, but seemed to possess a visible disk, the limb of *Jupiter* seeming to advance gradually upon it, the star, by-and-by, appearing to be bisected and then gradually disappearing altogether. The time of final disappearance was $10^h\ 7^m\ 47^s{\cdot}6$ M.M.T., at which instant the circle of *Jupiter's* limb appeared perfect; previous to this the star appeared as a small protuberance upon the limb, which *gradually* got smaller until final disappearance. The time of first contact was not noted, but I estimated the interval between contact and disappearance at about 35 seconds; certainly not less, it might be more. For about 10 seconds after disappearance the star could be seen *through Jupiter's* atmosphere as a speck of light seen through ground glass. This also disappeared *gradually*. There was no fitful disappearance and reappearance, but gradual disappearance throughout. . . . At $12^h\ 34^m\ 47^s$ I could clearly see a minute protuberance where the star was expected to appear. This protuberance exactly resembled the one-half of the disk-like appearance of the star at disappearance [the planet was then hidden by clouds and] at $12^h\ 37^m\ 57^s$ I got another clear view for about 10 seconds, when the star was seen well separated from *Jupiter*. The small protuberance noted three minutes previously was thus proved to be the reappearance of the star."

The same occultation was observed by Mr. Ellery with an 8-inch achromatic, power 300. He says: "The star first appeared to touch the planet's limb at $10^h\ 5^m\ 19^s$ M.M.T., and was

visible in that position for nearly two minutes, when, while still making a projection on the planet's outline, it all at once appeared as if seen through a mist or haze, *and entirely projected on the planet's limb.* This faded away in about ten seconds, leaving still a decided nipple-like projection on the edge of the planet, as if the planet itself bulged out, without any signs of the true light of the star; and at $10^h\ 7^m\ 43^s{\cdot}8$ this disappeared, leaving a clean outline to the disk."

Mr. E. J. White, of the Melbourne Observatory, who observed the occultation with a $4\frac{1}{2}$-inch achromatic, says that "Although the definition was very good in a cloudless sky, yet slight oscillations of the planet occurred which made the star momentarily disappear. At $10^h\ 6^m\ 23^s{\cdot}7$ M.M.T. I thought the star had really disappeared; but on looking again I saw it projected on *Jupiter* as a bright nipple, which seemed to gradually lessen in size till $10^h\ 7^m\ 40^s{\cdot}4$, when I finally lost sight of it."

Professor E. C. Pickering has kindly communicated to me the following note with reference to an occultation of a 7·3 magnitude star which he observed on April 14, 1883. The star occulted was D. M. $+23°{\cdot}1087$.



The diagram, which is made from a sketch given by Prof. Pickering, represents the variation in the intensity of the light of the star during the two and a quarter minutes before its final disappearance. His notes with respect to the observation run as follows:—

G.M.T. h m s		G.M.T. h m s	
14 21 17	Seen.	14 23 1	Not seen.
30	Seen with difficulty.	13	Suspected.
44	Suspected.	24	„
48	Seen.	34	Not seen.

"For about two minutes before final disappearance the star alternately disappeared and reappeared without obvious cause; seeing pretty good and uniform throughout. For twenty-six minutes the planet was carefully watched, and the star was again seen at $14^h\ 49^m\ 56^s$. The uncertainty in this time must have been very small, as the observer had not removed his eye from the telescope for some time previously. The star continued visible without the fluctuations noticed at disappearance. The occultation occurred near the northern limb of *Jupiter*. E. C. Pickering (observer), A. Searle (recorder)."

The observation was made with the 15-inch achromatic of Harvard College Observatory.

On April 14, 1883, *Jupiter* moved through a little less than 11″ of arc in twenty-six minutes of time, its motion amongst the stars being nearly parallel to the planet's equator, but slightly northward. In the two minutes and a half, the time which elapsed between the first change in the intensity of the light of the star and its final disappearance, the limb of the planet moved through about 1″·08. Taking *Jupiter's* distance from the Earth on April 14 as 507,610,000 miles, an arc of 1″·08 would correspond to a motion of the planet's limb through 2,600 miles. Assuming *Jupiter's* equatorial semi-diameter at the date of the observation to be 16″·6, and its polar semi-diameter to be 15″·6, the rays from the star passed through the planet's atmosphere at the time when the first change of intensity was observed, at a height of 890 miles above the level at which the rays were last transmitted just before the light of the star was extinguished.

If *Jupiter* had no atmosphere, and its limb were opaque, the region of total shadow cast by the planet would lie within an elliptical *conocuneus*, with its base upon the planet and its apex line at a distance of nearly seventy millions of miles beyond *Jupiter*; at the distance of the fourth satellite (1,192,000 miles) the elliptic section of the total shadow would be surrounded by a zone of penumbral shadow about 2,080 miles wide. The satellite itself has a diameter of 2,900 miles.

A refracting atmosphere about the planet would, by curving the Sun's rays inwards, tend to diminish the area of total shadow; but the time occupied by the satellites in traversing the shadow cone shows that the horizontal refraction of the Jovian atmosphere cannot be great at the height at which the Sun's light is extinguished in passing through the limb of the planet. There will always be some uncertainty as to the observed diameter of the shadow cone, for the satellites probably disappear before the Sun's disk is wholly eclipsed on the last portion of the disk of the satellite which enters the shadow. Observations of eclipses of our own Moon show that the Earth's shadow appears larger than the geometrical shadow which would be cast by a body as large as the Earth not surrounded by an atmosphere. Mädler estimated this increase of diameter as $\frac{1}{54}$th* (see *Astr. Nach.* xv. p. 29), and we know that clouds in our own atmosphere seldom, if ever, float at a height of ten miles above the sea level.

The Sun's disk at the distance of *Jupiter* has a diameter of less than 6′; and when the fourth satellite passes centrally through the shadow cone, any point on the satellite occupies about six and a half minutes in traversing the penumbral region.

* Mr. Godward informs me that the *Nautical Almanac* uses the fraction $\frac{1}{60}$ as representing the increase in the diameter of the observed shadow over the geometrical shadow thrown by the Earth. In the case of *Jupiter's* satellites, the predictions of eclipses are given as calculated for the geometrical shadow.

The satellite traverses its own diameter of 2,900 miles in about nine and a half minutes.

Taking into account the degradation of brightness towards the Sun's limb, we can hardly suppose that the Sun's light would be diminished so that the satellite would be lost sight of while a section of the Sun's disk with a versine of 1″·5 remained visible at a point half-way between the centre of the satellite and the following limb—that is to say, four minutes before the geometrical eclipse of the last portion of the Sun's disk at the following limb of the satellite. But even with the tables at present in use the predicted times for central eclipses of the fourth satellite do not differ from the observed times by as much as four minutes. We may consequently be sure that the horizontal refraction in the atmosphere of *Jupiter* at the height where the last ray is transmitted does not amount to 4′ of arc.

I would suggest that the spectrum of the light of the satellites should be examined as they disappear in the shadow of the planet, to see whether any evidence of absorption can be detected due to the long passage of the illuminating rays through the atmosphere of *Jupiter*.

Observations of U Monocerotis and LL 14551, *with a new Photometer.* By the Rev. T. E. Espin, B.A.

The following observations of U *Monocerotis* were made with a photometer and opera-glass. The photometer was attached to the 5-inch Refractor, and is of simple construction; a beam of light is cut off by a circular stop, and leaves a disk of light on a dark field. The beam of light is totally reflected by a prism to the eyepiece end from a small oil lamp, that can be turned up or down at pleasure. So long as the eyepiece is in focus the star will be seen on the bright and dark background alike; but by gradually drawing out the tube, the image of the star becomes a disk, which up to a certain point will be seen on the bright part of the field; but when the eye-piece is drawn out beyond that point, it will be invisible, being lost in the brightness. Obviously the brighter the star the further the tube must be drawn out to reach the point of disappearance. The method employed in determining the magnitude of a variable star is to measure one star whose magnitude is known, and is greater than the variable, and one whose magnitude is known and less than the variable.

The distance the tube is drawn out is read off by a scale from a mark on the telescope to some mark on the draw tube. The variable star is then measured. The magnitudes of the two comparison stars being known, the difference of readings will equal the difference of magnitudes, and it becomes a matter of simple proportion to find the magnitude of the variable star. The variable star U *Monoc.* was discovered by Dr. Gould, of